ABSTRACT

THE PREVALENCE OF MYOFASCIAL TRIGGER POINTS IN ASYMPTOMATIC OVERHEAD ATHLETES

The purpose of this study was to determine the prevalence myofascial trigger points (TPs) in asymptomatic overhead athletes. Glenohumeral rotation range of motion (ROM) of fifteen participants was measured on both the dominant and non-dominant arm. Following the ROM measures a second examiner, blinded to the ROM measurements, palpated for seven TPs in four muscles of the posterior shoulder: the posterior deltoid (1 TP), infraspinatus (3TPs), teres minor (1 TP), and latissimus dorsi (2 TP). These muscles apply braking force to assist in the deceleration of the upper extremity in order to prevent translation of the proximal humerus at the glenoid fossa (Borsa, Laudner, & Sauers, 2008). Chi-square tests were used to assess differences in prevalence of MTrPs between dominant and non-dominant arm. An alpha level of .05 was set a priori for all tests of significance. All analyses will be done with SPSS (V. 21, Chicago, IL). No significant differences ($P > .05$) were found between dominant and non-dominant arm, although a trend was noted with the trigger point identified in the infraspinatus (superior), which yielded a $P$ value of 0.069. The results suggest a relationship between decreased ROM and the prevalence of trigger points. All the participants had at least one trigger point. The assessment and treatment of trigger points may be necessary when examining the shoulder for potential injury and (or) decrease in performance.

Joseph Young Gil
August 2015
THE PREVALENCE OF MYOFASCIAL TRIGGER POINTS IN ASYMPTOMATIC OVERHEAD ATHLETES

by

Joseph Young Gil

A thesis
submitted in partial fulfillment of the requirements for the degree of
Master of Arts in Kinesiology
in the College of Health and Human Services
California State University, Fresno
August 2015
APPROVED
For the Department of Kinesiology:

We, the undersigned, certify that the thesis of the following student meets the required standards of scholarship, format, and style of the university and the student’s graduate degree program for the awarding of the master's degree.

Joseph Young Gil
Thesis Author

Scott Sailor (Chair) Kinesiology

Stephanie Moore-Reed Kinesiology

Mark Baldis Kinesiology

For the University Graduate Committee:

__________________________________________
Dean, Division of Graduate Studies
AUTHORIZATION FOR REPRODUCTION
OF MASTER’S THESIS

X I grant permission for the reproduction of this thesis in part or in its entirety without further authorization from me, on the condition that the person or agency requesting reproduction absorbs the cost and provides proper acknowledgment of authorship.

Permission to reproduce this thesis in part or in its entirety must be obtained from me.

Signature of thesis author: __________________________________________
ACKNOWLEDGMENTS

Thank you to everyone who contributed to this project especially Dr. Stephanie Moore-Reed, you are truly an inspiration to all of your students and I admire you greatly. I also want to thank my parents Chris and Sue, Dr. Mark Baldis, Dan Barrows, and Dr. Scott Sailor. And thank you to my cohort, who have provided lots of humor, exuberance, and encouragement since the beginning.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>LIST OF TABLES</th>
<th>vii</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHAPTER 1: INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>Statement of Purpose</td>
<td>2</td>
</tr>
<tr>
<td>Hypothesis</td>
<td>2</td>
</tr>
<tr>
<td>Significance of Study</td>
<td>2</td>
</tr>
<tr>
<td>Delimitations</td>
<td>3</td>
</tr>
<tr>
<td>Limitations</td>
<td>3</td>
</tr>
<tr>
<td>Definition of Terms</td>
<td>3</td>
</tr>
<tr>
<td>CHAPTER 2: REVIEW OF LITERATURE</td>
<td>7</td>
</tr>
<tr>
<td>Clinical Definition, Causes, and Effects</td>
<td>7</td>
</tr>
<tr>
<td>Identification</td>
<td>9</td>
</tr>
<tr>
<td>Prevalence and Treatment</td>
<td>10</td>
</tr>
<tr>
<td>Upper Extremity and Posterior Shoulder Tightness</td>
<td>11</td>
</tr>
<tr>
<td>PENN Shoulder Score</td>
<td>13</td>
</tr>
<tr>
<td>Summary</td>
<td>14</td>
</tr>
<tr>
<td>CHAPTER 3: METHODOLOGY</td>
<td>16</td>
</tr>
<tr>
<td>Participants</td>
<td>16</td>
</tr>
<tr>
<td>Procedures</td>
<td>16</td>
</tr>
<tr>
<td>Statistical Analysis</td>
<td>18</td>
</tr>
<tr>
<td>CHAPTER 4: RESULTS</td>
<td>19</td>
</tr>
<tr>
<td>CHAPTER 5: CONCLUSION</td>
<td>21</td>
</tr>
<tr>
<td>Conclusions</td>
<td>23</td>
</tr>
<tr>
<td>REFERENCES</td>
<td>24</td>
</tr>
</tbody>
</table>
APPENDICES .................................................................................................................................................. 29
APPENDIX A: CONSENT FORM .................................................................................................................. 30
APPENDIX B: PARTICIPANT DEMO/PENN SHOULDER SCORE ................................................................. 34
APPENDIX C: RANGE OF MOTION MEASUREMENT SHEET ................................................................... 38
APPENDIX D: TRIGGER POINT IDENTIFICATION SHEET ...................................................................... 40
LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table 1</td>
<td>Range of Motion Measures</td>
<td>19</td>
</tr>
<tr>
<td>Table 2</td>
<td>Presence of Trigger Points</td>
<td>20</td>
</tr>
</tbody>
</table>
CHAPTER 1: INTRODUCTION

As the result of sport-related activities such as pitching a baseball, hitting a serve in tennis, or spiking a volleyball, individuals who participate in overhead sports experience both bony and soft tissue adaptations. The resulting changes in shoulder mobility, specifically glenohumeral internal rotation deficit (GIRD), have encouraged researchers and clinicians to consider the potential compromise of shoulder stability. Due to the increased risk of injury to the shoulder, this potential instability is a cause for concern. Some debate has arisen as to how soft tissue or osseous adaptions actually affect alterations in mobility patterns (Borsa, Laudner, & Sauers, 2008). However, some authors have suggested that soft tissue is responsible for the loss in glenohumeral internal rotation range of motion as evidenced by the effectiveness of a stretching program focused on improved GH internal rotation ROM as well the acute effects of instrument-assisted soft tissue mobilization (IASTM) (Laudner, Compton, McLoda, & Walters, 2014; Lintner, Mayol, Uzodinma, Jones, & Labossiere, 2007). Other investigators have suggested that posterior shoulder tightness and glenohumeral range of motion deficits contribute to impingement and again, that stretching should be included in the management of the shoulder to restore flexibility (Myers, Laudner, Pasquale, Bradley, & Lephart, 2006).

Additionally, myofascial trigger points are common and can contribute to shoulder range of motion deficits and a loss in muscular strength (Lucas, 2008; Roach, Sorenson, Headley, & San Juan, 2013). A high prevalence of trigger points was found in a group of patients with chronic, non-traumatic shoulder pain, so the association between chronic shoulder pain and the presence of myofascial trigger points has been investigated (Bron, Dommerholt, Stegenga, Wensing, &
Oostendorp, 2011). However, the relationship between posterior shoulder tightness and the prevalence of myofascial trigger points (both latent and active) has not been investigated. By further inquiry and through the result of this study, clinicians may gain more tools to determine a diagnosis and management for varying musculoskeletal pathologies associated with overhead activities.

**Statement of Purpose**

The purpose of this study was to determine the prevalence myofascial trigger points in asymptomatic overhead athletes.

**Hypothesis**

It was hypothesized that the presence of myofascial trigger points would be greater in the dominant arm as compared to the non-dominant arm.

**Significance of Study**

The prevalence of myofascial trigger points in overhead athletes with posterior shoulder tightness is unknown and this investigation may be beneficial, particularly to clinicians as they examine biomechanical dysfunctions and (or) musculoskeletal pain of patients. Myofascial trigger points (MTrPs) are common, often causing pain, lack of mobility, and other physical conditions that can impair daily function. In the athletic population, it has potential implications for the prevention or treatment of sport injuries. No previous study has examined the relationship between prevalence of myofascial trigger points and ROM. The findings of the study may lead to increased emphasis on assessment and treatment of myofascial trigger points in the muscles of the posterior shoulder.
Delimitations

1. Recreational and competitive overhead athletes (volleyball, softball, baseball, tennis, water polo)
2. A Penn shoulder score of 26/30 or greater on the Pain subscale and 54/60 or greater on the function subscale
3. Diagnostic criteria from *Myofascial Pain and Dysfunction: The Trigger Point Manual* (Simons, Travell, & Simons, 1999)

Limitations

1. Lack of experience in measuring range of motion
2. Ability to identify trigger points
3. The proposed study examines only asymptomatic subjects, though myofascial trigger points have been suggested to be a cause for both chronic and acute pain. (Bron et al., 2011)
4. Cannot generalize to symptomatic population

Definition of Terms

For the purposes of this study, the following terms are defined.

Active trigger point (ATrP): A myofascial trigger point that causes a clinical pain complaint. It is always tender, prevents full lengthening of the muscle, weakens the muscle, refers a patient-recognized pain on direct compression, mediates a local twitch response, mediates a local twitch response of muscle fibers when adequately stimulated, and, when compressed within the patient’s pain tolerance, produces referred motor phenomena and often autonomic phenomena, generally in its pain reference zone and causes tenderness in the pain reference zone (Simons et al., 1999, p. 1)
**Agonists:** Muscles, or portions of muscles, so attached anatomically that when they contract they develop forces that complement or reinforce each other (Simons et al., 1999, p. 1)

**Antagonists:** Muscles, or portions of muscles, so attached anatomically that when they contract they develop forces that oppose each other (Simons et al., 1999, p. 2)

**Asymptomatic:** A Penn shoulder score of > 26/30 on the Pain subscale and 54/60 or greater on the function subscale to participate (Kerins, Moore, Butterfield, McKeon, & Uhl, 2013)

**Flat Palpation:** Examination by finger pressure that proceeds across the muscle fibers at a right angle to their length, while compressing them against a firm underlying structure, such as bone” (Simons et al., 1999, p. 3)

**Glenohumeral External Rotation Range of Motion (GER):** The extent of external rotation movement at the glenohumeral joint with the involved arm abducted 90º

**Glenohumeral Internal Rotation Deficit (GIRD):** The loss of internal rotation compared with the opposite side and is attributable to both bony and soft tissue changes (Lintner et al., 2007, p. 618)

**Glenohumeral Internal Rotation Range of Motion (GIR):** The extent of internal rotation movement at the glenohumeral joint with the involved arm abducted 90º

**Instrument-assisted soft tissue mobilization (IASTM):** A technique whereby an implement is used to localize and treat soft tissue restrictions (Laudner et al., 2014)
Jump sign: A general pain response of the patient, who winces, may cry out, and may withdraw in response to pressure applied on a trigger point (Simons et al., 1999, p. 4)

Latent trigger point (LTrP): A myofascial trigger point that is clinically quiescent with respect to spontaneous pain; it is painful only when palpated (Simons et al., 1999, p. 4)

Local twitch response: A transient contraction of a group of tense muscle fibers (taut band) that traverse a trigger point. The contraction of the fibers is in response to stimulation (usually by snapping palpation or needling) of the same trigger point, or sometimes of a nearby trigger point (Simons et al., 1999, p. 4)

Myofascial trigger point (MTrP): A hyperirritable spot in skeletal muscle that is associated with a hypersensitive palpable nodule in a taut band (Simons et al., 1999, p. 9)

Overhead athlete: An individual who participates competitively and recreationally in an overhead sport and is consequently at risk of degenerative and traumatic injuries at the glenohumeral joint

Passive Range of Motion: The extent of movement (usually tested in a given plane) of an anatomical segment at a joint when movement is produced by an outside force without voluntary assistance or resistance by the subject. The subject must relax the muscles crossing the joint (Simons et al., 1999, p. 6)

Posterior Shoulder Tightness: ≥15° deficit in glenohumeral internal rotation and ≥10° deficit in total arc of motion (TAM) in one arm compared to the contralateral limb (Kerins et al., 2013)

Referred (Trigger-point) pain: Pain that arises in a trigger point, but is felt at a distance, often entirely remote from its source. The pattern of referred pain is reproducibly related to its site of origin (Simons et al., 1999, p. 6)
Snapping Palpation: A fingertip is placed against a taut band of muscle at right angles to the direction of the band and suddenly pressed down while the examiner draws the finger back so as to roll the underlying fibers under the finger (Simons et al., 1999, p. 7)

Synergistic Muscles: Muscles that reinforce or complement each other when they contract (Simons et al., 1999, p. 7)

Taut Band: The group of tense muscle fibers extending from a trigger point to the muscle attachments (Simons et al., 1999, p. 7)

Total Range of Motion: Sum of GIR and GER
CHAPTER 2: REVIEW OF LITERATURE

Myofascial trigger points (MTrPs) are common, often causing pain, impaired mobility and ROM, and other physical conditions that can impair daily function. They can be defined as “a hyperirritable spot in skeletal muscle that is associated with a hypersensitive palpable nodule in a taut band” and frequently develop in the shoulder, leading to pain and injury (Simons et al., 1999, p. 7). The definitions, clinical importance, identification, prevalence, treatment of MTrPs, and its impact on shoulder function and pain will be discussed.

Clinical Definition, Causes, and Effects

MTrPs are classified as latent or active. Latent trigger points (LTrPs) produce pain only when the nodule in the taut band is palpated. Active trigger points (ATrPs) are associated with referred pain and are able to induce pain during motion and/or at rest, regardless of palpation (Bron et al., 2011; Simons et al., 1999). Changes in sensation, which include referred pain, central and peripheral sensitization, and local tenderness, is the primary way in which TPs are differentiated and identified. TPs may affect movement patterns due to resulting muscle weakness (due to muscle inhibition), restriction in range of motion, and muscle stiffness (Travell & Simons, 1992).

MTrPs can develop in a number of ways. Treaster, Marras, Burr, Sheedy, and Hart (2006) found that low-level muscle contractions that are sustained for a prolonged period of time can lead to the development of TPs. An activity, such as continuous typing for as short as 30 min, has been shown result in the formation of TPs. Dommerholt, Bron, and Franssen (2006) reported other occupations that are subject to these low-level muscle exertions include dentists, office workers, and musicians. It has been reported that there is a general consensus among clinicians
that an acute overload (direct trauma) to musculature can lead to the development of TPs (Dommerholt et al., 2006). Acute overload can occur during whiplash injury, direct impact to musculature, sports performance, lifting injuries, etc. (Dommerholt, Royson, & Whyte-Ferguson, 2005).

LTrPs have the ability to inhibit musculoskeletal function (Lucas, 2008). Lucas et al. (2004) investigated the effect of LTrPs on muscle activation patterns (MAPs) in the shoulder girdle and found that subjects that had at least one LTrP in the scapular rotator muscles of the dominant arm displayed abnormal MAPs when compared to LTrP-free subjects (control). Muscle activation time was significantly different ($P < 0.05$) in the LTrP group and variability for the group was also significantly greater ($P < 0.05$) (Lucas, Rich, and Polus, 2004). The results indicated a delay in muscle activation in the LTrP group, “suggesting some sort of inhibitory process and resulting in an increased potential for impingement of subacromial structures” (Lucas et al., 2004).

Ibarra et al. (2011) found that the presence of LTrPs were associated with increased antagonistic muscle activity during agonist muscle contraction, which would result in reduced force output. With the contraction of a given muscle group, there is coordination between the contracting muscles and simultaneous relaxation of the antagonist muscles during movement (Chaitow, 2001). If relaxation of antagonist muscles is inhibited, the force output of the agonist muscles is potentially reduced. Ge, Monterde, Graven-Nielsen, and Arendt-Nielsen (2014) reported similar findings when investigating the association between LTrP and synergistic muscle contraction. In the study, asymptomatic subjects were asked to abduct their dominant shoulder to 90°, at varying loads, while EMG data were collected from their middle deltoid (primary agonist) and the trapezius (synergist). When comparing the intramuscular EMG activity of
LTrPs present in the trapezius to nontrigger points within the same muscle, intramuscular EMG for the LTrPs was significantly higher ($P < .0001$), particularly during isometric contraction (Ge, Monterde, Graven-Nielsen, & Arendt-Nielsen, 2014). Ge et al. suggested that the increased intramuscular hyperactivity overloads synergists during movement and can contribute to increased pain sensitivity. They concluded that there was impairment with muscle recruitment and overall patterns of motor control in synergistic muscles that had LTrPs (Ge et al., 2014). These conclusions warrant further clinical examination and research, especially for individuals who have LTrPs, who may not be aware of their impaired motor control due to their lack of symptoms.

Identification

As further research is conducted on the clinical implications of MTrPs, it is clear that the methods used to identify them are highly inconsistent. However, the diagnostic criteria often cited among qualified clinicians and researchers are the recognition of pain by the patient during palpation of the trigger point and (or) referred pain (Tough, White, Richards, & Campbell, 2007). Accurate identification of TPs seems to be based solely on the breadth of clinical experience of the examiner. While more accurate assessments of MTrPs are being developed, researchers must be more precise in their own operational definitions and procedures of identification (Tough et al., 2007). Palpation is the primary method in which TPs are assessed, yet, there is only moderate evidence to support it reproducibility in examining local tenderness of the gluteus medius, quadratus lumborum, and trapezius muscles (Tough et al., 2007). As previously mentioned, assessment and identification of TPs are typically based on the practitioner’s experience.
Objective and universal criteria is needed to improve clinical diagnosis and research findings of TPs. Even if improved diagnostic techniques are developed, palpation may still prove to be a viable method to identify TPs. Intrarater reliability of demonstrating the presence of spot tenderness, taut bands, pain recognition, and jump sign between sessions has been shown, but the ability for the results to be generalized is still in question.

The use of magnetic resonance imaging (MRI), when applying a new technique known as magnetic resonance elastography (MRE) could be a promising new diagnostic technique for TPs. MRE is a relatively new development in imaging techniques. Initially utilized for the purpose of analyzing different soft tissues including cancerous breast tissue, MRE uses phase contrast imaging to identify stiffness in tissue (Myburgh, Larsen, & Hartvigsen, 2008). It is now known that the MRE technique is capable of quantifying taut bands and other muscular dysfunction that is present in individuals with myofascial pain, however, isolating and identifying actual TPs using an MRI merits further research (Muthupillai et al., 1995). Future developments in MRE may produce a standard by which MTrPs can be measured and quantified.

**Prevalence and Treatment**

As mentioned previously, overuse of certain muscles can lead to the development of TPs in those particular regions. As a result, athletes are potentially more prone to TPs (Chen, Bensamoun, Basford, Thompson, & An, 2007). A recent study showed 97% of subjects with patellofemoral pain had at least one MTrP in the gluteus medius, a muscle that is suggested to be linked with movement at the patellofemoral joint (Byrne, Twist, & Eston, 2004; Roach et al., 2013). In contrast, 23% of subjects without a history of patellofemoral pain had at
least one TP in the gluteus medius (Roach et al., 2013). The prevalence of TPs has also been examined in a broader asymptomatic population. Lucas, Rich, and Polus (2008) determined the prevalence of LTrPs in the scapular positioning muscles (rhomboids, trapezius, serratus anterior, levator scapulae, and pectoralis minor) of the 154 subjects that were assessed, nearly 90% had least one TP.

Treatments that have been used to restore function and reduce pain for myofascial TPs are numerous and can be separated into three categories; manual therapies (D'Ambrogio, Roth, Robertson, Halperin, & Wiley, 1997), “muscle energy techniques (Chaitow, 2001), and other modalities including thermotherapy (Lee, Lin, & Hong, 1997), ultrasound therapy (Gam et al., 1998), laser therapy (Pöntinen & Airaksinen, 1995)” (De Las Penas, Sohrbeck Campo, Fernandez Carnero, & Miangolarra Page, 2005, pp. 28-29). The effectiveness of manual therapy techniques on TPs, validity is in question due to the lack of agreement on physical examination, particularly the diagnostic criteria. Many of the studies, have not provided evidence of the efficacy of manual therapy beyond the effect of placebo. While clinicians may find some efficacy in implementing manual therapy techniques to their patients, future research is need to substantiate claims of effectiveness past placebo (De Las Penas et al., 2005).

**Upper Extremity and Posterior Shoulder Tightness**

Upper extremity pathology and dysfunction are an area of concern for overhead athletes. The overuse or trauma to the musculoskeletal structures involved can decrease performance (Myers et al., 2006). For overhead athletes, such as baseball, tennis, or handball players, to be successful and competitive, the shoulder girdle must have adequate range of motion to allow for sufficient arm ROM during the cocking phase, thus leading to increased ball velocity.
Concurrently, the shoulder girdle must be sufficiently stable in order to prevent injury. This apparent contradiction is known as the “thrower’s paradox.” This overhead, throwing type motion involves rapid and forceful movement of the arm at the glenohumeral joint from near-maximal or maximal external rotation, horizontal abduction, and flexion to internal rotation, horizontal adduction, and extension. The muscles of the posterior rotator cuff must apply a braking force to assist in the deceleration of the upper extremity in order to prevent distraction and/or translation of the humeral head at the glenoid fossa (Borsa et al., 2008). The structures involved include, the glenohumeral joint, posterior deltoid, latissimus dorsi, teres major, teres minor, and infraspinatus muscles (Laudner et al., 2014).

Baseball players in particular, experience changes primarily in their throwing arm, as evidenced by a larger range of motion in external rotation and a decrease in both internal rotation and horizontal adduction. Adaptations to both soft and bony tissue in the shoulder can result in these changes in range of motion (Laudner, Stanek, & Meister, 2006; Myers et al., 2009). The loss of internal rotation is commonly known as Glenohumeral Internal Rotation Deficit (GIRD), along with posterior shoulder tightness, may contribute to impingement syndrome. Some findings suggest stretching as a way of managing the loss of flexibility to the shoulder (Myers et al., 2006). While researchers have examined the effectiveness of various stretching techniques on improvement glenohumeral range of motion, the inconsistency and variability of the outcomes have contributed to the confusion concerning the most appropriate stretching techniques (Laudner et al., 2014; Lintner et al., 2007). Very few studies have investigated instrument assisted soft tissue mobilization and its efficacy on managing glenohumeral range of motion, warranting the need for further research. However,
in the limited studies that have been done, there have been findings that show significant improvements in glenohumeral internal rotation ROM and glenohumeral adduction ROM with the use of instrument assisted soft tissue mobilization (IASTM). In an experiment using the Graston® Technique (a form of IASTM), investigators observed an increase in GH adduction ROM of 11.1º, as opposed to -1.12º in the control group. For GH internal rotation ROM, subjects who received the intervention gained 4.8º, with the control being at a slight deficit at -0.14º (Laudner et al., 2014).

These findings support the rationale of soft tissue adaptations and their significant contribution in response to the physical stresses overhead athletes incur to their shoulders. Additionally, internal rotation deficits at the glenohumeral joint can be addressed with a regularly completed stretching program emphasizing internal rotation, since the deficit has been attributed to soft tissue adaptations (Lintner et al., 2007). There have been investigations on the prevalence of MTrPs in musculature of the shoulder, but none has associated the prevalence with tightness (Bron et al., 2011).

**PENN Shoulder Score**

The Penn Shoulder Score (PSS) was developed in 1999, as an outcome tool for self-report consisting of three subscales concerning the shoulder, including satisfaction, pain, and function (Leggin et al., 2006). It is a 100-point scale, with the subscale for pain being out of a possible 30 points; subjects report based on three items, pain with normal activities, strenuous activities, and at rest. If no point pain is present for each of the three items, the subject is given 30 points for “complete absence of pain.” If for example, the individual is unable to use their arm during strenuous or normal activities, they receive 0 points for that item.
The following section of the PSS is a 10-point numeric rating scale for satisfaction with the function of the shoulder, starting at “not satisfied” and ending at “very satisfied” indicating a maximum of 10 points. The final subsection is comprised of 20 items related to function, with each having a 4-point Likert scale. “The response options include 0 (can’t do at all), 1 (much difficulty), 2 (with some difficulty), and 3 (no difficulty)” (Leggin et al., 2006, p. 139). An individual scoring 60 points would be able to perform all the activities without difficulty. Having a total score of 100(maximum) indicates low pain, high satisfaction, and high function.

The PSS has been compared to the American Shoulder and Elbow Surgeons (ASES) score, another outcome measure for the shoulder consisting of 2 dimensions, activities of daily living and pain. In a study assessing the reliability and validity of the ASES score, researchers demonstrated convergent construct validity with the PSS in reporting a correlation of .78 (Leggin et al., 2006). The PSS has also been tested for reliability and validity and has been shown to be a reliable and valid outcome tool for individuals with various shoulder conditions. “Reliability analysis revealed a test-retest ICC$_{2,1}$ of 0.94 (95% CI, 0.89-0.97). Internal consistency analysis revealed a Cronbach alpha of 0.93” (Leggin et al., 2006, p. 138).

**Summary**

Examining the relationship between the prevalence of trigger points and ROM may provide insight on soft tissue adaptations. As mentioned previously, there is a lack of research investigating this relationship. The information obtained from this study will contribute to the general body of knowledge of
shoulder examination and aid health care professionals in correctly assessing patients with potential causes of shoulder pain.
CHAPTER 3: METHODOLOGY

This chapter will describe the procedures used to fulfill the objectives of this study. It is divided into participants, procedures, and statistical analysis.

Participants

The study consisted of 15 male and female collegiate overhead athletes (3 men, 12 women; mean age ± SD; 19±1y; mean height ± SD, 174±12cm; mean mass ± SD, 79±14kg). The 3 male participants were baseball pitchers, the other female participants played softball (9) or volleyball (3). Those selected for this study met the following criteria: collegiate overhead athlete (volleyball, softball, baseball, tennis, water polo), a PENN shoulder score of ≥26/30 on the Pain subscale and ≥54/60 on the function subscale as those scores would indicate fully functional and relatively pain-free shoulder(s) (Kerins et al., 2013). Requirement of classification of posterior shoulder tightness was a unilateral deficit of ≥10° of passive total range of motion and (or) ≥15° deficit in glenohumeral internal rotation with the dominant arm compared to the non-dominant arm.

Procedures

No research was conducted until human subjects approval was granted by the Institutional Review Board at California State University, Fresno. Data collection for each subject required one session of approximately 15 min and took place on the Fresno City College campus and at Fresno State in the Human Performance Laboratory (HPL) located in the South Gymnasium, Room 139. All participants read and signed informed consent prior to participation (see Appendix A). Participants completed the Demographic Questionnaire and the Penn Shoulder Score (PSS), to determine if they were able to meet eligibility
requirements (see Appendix B) (Leggin et al., 2006). After filling out the PSS, each subject was asked to lie down on a plinth in a supine position and measures of glenohumeral internal rotation (GIR) and glenohumeral external rotation (GER) ROM was taken bilaterally with a digital inclinometer (see Appendix C) (a Dualer IQ Pro™ digital inclinometer) (Moore, Laudner, McLoda, & Shaffer, 2011). The arm was abducted to 90° in the frontal plane with the elbow in 90° of flexion. The inclinometer was placed on the forearm just proximal to the wrist and the arm was moved passively to the end range of motion. The end point was just prior to the point at which the anterior aspect of the shoulder moves anteriorly, indicating the end of glenohumeral (start of scapular motion) (McClure et al., 2007). Intratester reliability of ROM measurements was established a priori. Thirty shoulders with no history of injury or surgery were measured and reassessed at a minimum of 48 hours later. Intraclass correlation coefficient (ICC) with 95% confidence interval (CI) was calculated for GIR ROM (ICC = 0.98) and GER ROM (ICC = 0.88).

After determining tightness in the posterior shoulder or lack thereof, a second examiner (Licensed Physical Therapist with experience in manual therapy), blinded to the ROM measurements, palpated for seven TPs in four muscles: the posterior deltoid (1 TP), infraspinatus (3TPs), teres minor (1 TP), and latissimus dorsi (2 TP) (see Appendix D). A previous study has shown test-reliability following the clinical diagnostic characteristics of myofascial trigger points: taut band, spot tenderness, jump sign, pain recognition, referred pain and local twitch responses (Al-Shenqiti & Oldham, 2005).

Information regarding the location of MTrPs were drawn from Myofascial Pain and Dysfunction: The Trigger Point Manual (1999), which is the primary authoritative source on MTrP diagnostic criteria (Tough et al., 2007).
Each participant was assessed on a plinth in prone, supine, and side lying positions.

**Statistical Analysis**

Descriptive statistics were used to report demographic information of the participants. Chi-square tests were used to assess differences in prevalence of MTrPs between dominant and non-dominant arms. An alpha level of .05 was set a priori for all tests of significance. All analyses were done with SPSS (V. 21, Chicago, IL).
CHAPTER 4: RESULTS

This chapter presents the results of the collected data as described in Chapter 3. Table 1 depicts the range of motion measurements for both dominant and non-dominant arm. Table 2 represents the number of trigger points identified in four posterior shoulder muscles of both dominant and non-dominant arm, the infraspinatus, latissimus dorsi, posterior deltoid, and teres minor. No significant differences were found between dominant and non-dominant arm, although a trend was noted with the superior infraspinatus trigger point ($P= 0.069$).

Table 1

<table>
<thead>
<tr>
<th>Range of Motion Measures</th>
<th>Dominant</th>
<th>Non-dominant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal Rotation ROM</td>
<td>$67 \pm 9.2$</td>
<td>$67.2 \pm 9.2$</td>
</tr>
<tr>
<td>External Rotation ROM</td>
<td>$105 \pm 12.3$</td>
<td>$95.9 \pm 9.8$</td>
</tr>
<tr>
<td>TROM</td>
<td>$172 \pm 10.3$</td>
<td>$163 \pm 9.2$</td>
</tr>
<tr>
<td>GIRD</td>
<td>$1 \pm 9$</td>
<td></td>
</tr>
<tr>
<td>TROM Deficit</td>
<td>$-9.7 \pm 11.6$</td>
<td></td>
</tr>
</tbody>
</table>

*Note.* Values are presented as Mean ± Standard Deviation.

GIRD = Glenohumeral Rotation Deficit; TROM = Total Range of Motion
Table 2

*Presence of Trigger Points*

<table>
<thead>
<tr>
<th>Muscles</th>
<th>Dominant</th>
<th>Non-dominant</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infraspinatus (distal)</td>
<td></td>
<td></td>
<td>0.107</td>
</tr>
<tr>
<td>Yes</td>
<td>6 (40%)</td>
<td>2 (13%)</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>9 (60%)</td>
<td>13 (87%)</td>
<td></td>
</tr>
<tr>
<td>Infraspinatus (superior)</td>
<td></td>
<td></td>
<td>0.068</td>
</tr>
<tr>
<td>Yes</td>
<td>5 (33%)</td>
<td>10 (67%)</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>10 (67%)</td>
<td>5 (33%)</td>
<td></td>
</tr>
<tr>
<td>Infraspinatus (inferior)</td>
<td></td>
<td></td>
<td>0.269</td>
</tr>
<tr>
<td>Yes</td>
<td>10 (67%)</td>
<td>7 (47%)</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>5 (33%)</td>
<td>8 (53%)</td>
<td></td>
</tr>
<tr>
<td>Latissimus Dorsi (inferior)</td>
<td></td>
<td></td>
<td>0.107</td>
</tr>
<tr>
<td>Yes</td>
<td>6 (40%)</td>
<td>2 (13%)</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>9 (60%)</td>
<td>13 (87%)</td>
<td></td>
</tr>
<tr>
<td>Latissimus Dorsi (superior)</td>
<td></td>
<td></td>
<td>0.136</td>
</tr>
<tr>
<td>Yes</td>
<td>7 (47%)</td>
<td>11 (73%)</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>8 (53%)</td>
<td>4 (27%)</td>
<td></td>
</tr>
<tr>
<td>Posterior Deltoid</td>
<td></td>
<td></td>
<td>0.299</td>
</tr>
<tr>
<td>Yes</td>
<td>1 (7%)</td>
<td>3 (20%)</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>14 (93%)</td>
<td>12 (80%)</td>
<td></td>
</tr>
<tr>
<td>Teres Minor</td>
<td></td>
<td></td>
<td>0.269</td>
</tr>
<tr>
<td>Yes</td>
<td>8 (53%)</td>
<td>5 (33%)</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>7 (47%)</td>
<td>10 (67%)</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>0.409</td>
</tr>
<tr>
<td>Yes</td>
<td>43 (41%)</td>
<td>40 (38%)</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>62 (59%)</td>
<td>65 (62%)</td>
<td></td>
</tr>
</tbody>
</table>
CHAPTER 5: CONCLUSION

The purpose of this study was to examine the prevalence of myofascial trigger points in asymptomatic collegiate overhead athletes. Glenohumeral range of motion was measured for both the dominant and non-dominant arm to assess any soft tissue changes as result of overhead activity to infer a relationship (if any) between shoulder range of motion and the prevalence of trigger points. Simons et al. (1999) have suggested that one of the perpetuating factors responsible for the formation of trigger points is mechanical stress. Prolonged, rapid, and repetitive movement (such as throwing, spiking, or serving) can contribute to the formation of trigger points. Therefore, it was hypothesized that the participants would have more trigger points in their dominant arm as compared with their non-dominant arm. The results of the study showed no significant differences between the number of trigger points found in four posterior shoulder muscles of the dominant arm compared with the non-dominant arm.

Bron et al. (2011) conducted a study on the prevalence of myofascial trigger points of 17 shoulder girdle muscles in patients with shoulder pain and found that the infraspinatus and trapezius were the most common muscles to have trigger points among the patients. While the trapezius was not examined in the current study, assessment of the infraspinatus demonstrated a trend ($P=0.068$) towards greater prevalence in the non-dominant arm as compared to the dominant arm. This finding was unexpected as it was hypothesized that more trigger points would be present in the dominant arm due to repetitive overhead activity. Therefore the inclusion of biomechanical analysis (including measurement of force production) of the subjects’ overhead movement may be needed to potentially provide greater insight to the perpetuation and prevalence of trigger points.
points. Other potential perpetuating factors may be an area of focus, such as nutritional inadequacies, metabolic and endocrine inadequacies, as well as psychological factors (Simons et al., 1999). Future investigations may also want to examine more than the four muscles (infraspinatus, latissimus dorsi, posterior deltoid, and teres minor) used in the current study.

As mentioned previously, due to the small sample size the results may not be applicable to all collegiate baseball, softball, and volleyball players. The participant pool included more females, who are potentially more prone to musculoskeletal disorders in general (Rollman & Lautenbacher, 2001). Also, the assessment of just four posterior shoulder muscles (infraspinatus, latissimus dorsi, posterior deltoid, and teres minor) could possibly have yielded different results if more muscles such as the trapezius, teres major, pectoralis minor, biceps brachii, etc. were assessed.

Out of the 15 total participants, only 3 exhibited GIRD. GIRD was defined as a unilateral deficit of $\geq 10^\circ$ of passive total range of motion and (or) $\geq 15^\circ$ deficit in glenohumeral internal rotation with the dominant arm compared to the non-dominant arm. These requirements for GIRD may have been too stringent to include more than just the 3 participants who were baseball pitchers, which suggests that greater forces (i.e., mechanical stress) leads to GIRD (Simons et al., 1999). Given the substantial loss in internal rotation range of motion due to soft tissue changes, it was hypothesized that those with GIRD would display a higher prevalence of trigger points. The number of trigger points identified in those who had GIRD was similar to those without GIRD. However, given the small sample size and even fewer participants who had GIRD, future studies may yield differing results when comparing prevalence of trigger points between individuals with and without GIRD.
Conclusions
In a sample of 15 collegiate baseball, softball, and volleyball players, all the participants had at least one trigger point and although trigger points may not cause immediate pain, they can produce referred pain when mechanically stimulated during repeated or sustained muscle contraction. Additionally, myofascial trigger points can disrupt movement efficiency and normal motor recruitment (Bron et al., 2011). Therefore, assessment and identification of trigger points may be reasonable when examining the shoulder for potential injury and (or) decrease in performance.
REFERENCES


APPENDICES
APPENDIX A: CONSENT FORM
Consent Form

Co-Investigator: Joseph Gil (B.S., M.A. in Kinesiology in progress)

The purpose of this study is to determine the prevalence of myofascial trigger points in asymptomatic athletes with posterior shoulder tightness. You were selected for possible participation in this study based on your participation in an overhead sport or activity. If you decide to participate, you will be required to attend 1 session in the Human Performance Laboratory (HPL) located in the South Gymnasium, Room 139 or a physical therapy or athletic training room convenient to you.

During the visit to the HPL, you will give informed consent, be introduced to the various equipment that will be used for data collection and receive instructions regarding the experimental protocol. You will then be assessed for posterior shoulder tightness as described as a deficit of 15-degrees or more for internal rotation and 10-degrees or more of total loss in the dominant arm. Measures of glenohumeral internal and external rotation and horizontal adduction will be taken bilaterally with a Dualer IQ Pro™ digital inclinometer. You will be asked to lie down face-up on an examination table for the measurements. After determining tightness in the posterior shoulder or lack thereof, the first set of data will be collected, a second examiner, blinded to the range of motion measurements, will apply pressure over the skin around the shoulder to locate
tender areas known as trigger points, specifically, the areas will include in four muscles, the posterior deltoid, infraspinatus, teres minor, and latissimus dorsi.

Any information that the investigators obtain during your participation in this study that could be identified with you will be kept confidential and never be disclosed without your consent. All personal information will be kept in a locked file cabinet in the Human Performance Laboratory (HPL) at Fresno State University, Department of Kinesiology. A copy of your data may be requested at any time. By signing this document, you are consenting to allow the results of this study to be made public via submission to scientific journals and presentation at professional conferences. The results of this study are intended to expand the body of scientific knowledge in regards to the relationship between posterior shoulder tightness and the prevalence of trigger points. Benefits that may come from participation in this study include information regarding more thorough assessment of function and range of motion than is typically provided. Your results may also be used to establish a baseline upon which subsequent training adaptations can be measured. The risks of this study are minimal and do not exceed those of a routine physical examination by a therapist.

Whether you consent or decline to participate in this study, your decision will not influence your future relationship with Fresno State. If you opt to volunteer, you may withdraw consent at any time and cease involvement without repercussions. The Committee on the Protection of Human Subjects at Fresno
State has given approval of these methods. This committee may be contacted at (559) 278-2083.

If you have any comments or questions you may contact Dr. Scott Sailor at (559) 278-2543 (ssailor@csufresno.edu) or myself, Joseph Gil at (559) 278-4738 or (559) 709-4388 (joesgils@me.com). You will receive a copy of this document for your own records.

BY SIGNING ON THE LINE BELOW YOU ARE PROVIDING YOUR CONSENT TO PARTICIPATE IN THIS STUDY AND UNDERSTAND THE INFORMATION PRESENTED ABOVE.

______________________________  ______________________________
Date                                      Signature

______________________________  ______________________________
Signature of Witness                  Signature of Investigator
APPENDIX B: PARTICIPANT DEMO/PENN SHOULDER SCORE
Date: __/__/____

Name: ____________________

For subject completion:
DOB (mm/dd/yy): ____/____/____  Height : ______  Weight (lbs): ______

Age: ____ (years)  Race: ______________  Gender:  1 = Female; 2 = Male

1. With which arm would you throw a ball?
   (Circle One)  1 = Right
               2 = Left

2. Do you have a known shoulder or neck problem/pathology?
   (Circle One)  1 = Yes
               2 = No

3. Have you had shoulder surgery within the past year?
   (Circle One)  1 = Yes
               2 = No

If “yes” to questions 1 or 2, please describe:
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

4. Have you received a steroid injection (such as cortisone) in either shoulder
   within the past month?
   (Circle One)  1 = Yes
               2 = No

5. On the scale below, please rate your current shoulder pain at rest?
   (0 = no pain; 10 = worst possible pain)
   0—1—2—3—4—5—6—7—8—9—10

6. Do you ever experience numbness or tingling in either shoulder and/or arm?
   (Circle One)  1 = Yes
               2 = No

Please continue on to the next page ➔
### PENN SHOULDER SCORE

**Part I: Pain & Satisfaction:** Please circle the number closest to your level of pain or satisfaction

<table>
<thead>
<tr>
<th>Pain at rest with your arm by your side:</th>
<th>(0 - 10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 1 2 3 4 5 6 7 8 9 10</td>
<td>Worst Pain</td>
</tr>
<tr>
<td>No Pain</td>
<td></td>
</tr>
<tr>
<td>Possible</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pain with normal activities (eating, dressing, bathing):</th>
<th>(0 - 10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 1 2 3 4 5 6 7 8 9 10</td>
<td>Worst Pain</td>
</tr>
<tr>
<td>No Pain</td>
<td></td>
</tr>
<tr>
<td>Possible</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pain with strenuous activities (reaching, lifting, pushing, pulling, throwing):</th>
<th>(0 - 10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 1 2 3 4 5 6 7 8 9 10</td>
<td>Worst Pain</td>
</tr>
<tr>
<td>No Pain</td>
<td></td>
</tr>
<tr>
<td>Possible</td>
<td></td>
</tr>
</tbody>
</table>

**PAIN SCORE:**

= ___/30 (9)

**How satisfied are you with the current level of function of your shoulder?**

<table>
<thead>
<tr>
<th>0 1 2 3 4 5 6 7 8 9 10</th>
<th>Not Satisfied</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Satisfied</td>
<td>(9)</td>
</tr>
</tbody>
</table>

= ___/10 (9) (9)
<table>
<thead>
<tr>
<th>Part II: Function: Please circle the number that best describes the level of difficulty you might have performing each activity.</th>
<th>No difficulty</th>
<th>Some difficulty</th>
<th>Much difficulty</th>
<th>Can't do at all</th>
<th>Did not do before injury</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Reach the small of your back to tuck in your shirt with your hand.</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>X</td>
</tr>
<tr>
<td>2. Wash the middle of your back/hook bra.</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>X</td>
</tr>
<tr>
<td>3. Perform necessary toileting activities.</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>X</td>
</tr>
<tr>
<td>4. Wash the back of opposite shoulder.</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>X</td>
</tr>
<tr>
<td>5. Comb hair.</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>X</td>
</tr>
<tr>
<td>6. Place hand behind head with elbow held straight out to the side.</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>X</td>
</tr>
<tr>
<td>7. Dress self (including put on coat and pull shirt on overhead.</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>X</td>
</tr>
<tr>
<td>8. Sleep on affected side.</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>X</td>
</tr>
<tr>
<td>9. Open a door with affected side.</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>X</td>
</tr>
<tr>
<td>10. Carry a bag of groceries with affected arm.</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>X</td>
</tr>
<tr>
<td>11. Carry a briefcase/small suitcase with affected arm.</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>X</td>
</tr>
<tr>
<td>12. Place a soup can (1-2 lbs.) on a shelf at shoulder level without bending elbow.</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>X</td>
</tr>
<tr>
<td>13. Place a one gallon container (8-10 lbs.) on a shelf at Shoulder level without bending elbow.</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>X</td>
</tr>
<tr>
<td>14. Reach a shelf above your head without bending your elbow.</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>X</td>
</tr>
<tr>
<td>15. Place a soup can (1-2 lbs.) on a shelf overhead without bending your elbow.</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>X</td>
</tr>
<tr>
<td>16. Place a one gallon container (8-10 lbs.) on a shelf Overhead without bending your elbow.</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>X</td>
</tr>
<tr>
<td>17. Perform usual sport/hobby.</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>X</td>
</tr>
<tr>
<td>18. Perform household chores (cleaning, laundry, cooking).</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>X</td>
</tr>
<tr>
<td>19. Throw overhand/swim/overhead raquet sports. (circle all that apply to you)</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>X</td>
</tr>
<tr>
<td>20. Work full-time at your regular job.</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>X</td>
</tr>
</tbody>
</table>

**SCORING:**
Total of columns = (a)  
Number of "X"s" x 3 = (b), 60 - (b) = (c)  
(if no "X"s" are circled, function score = total of columns)  
Function Score = ______(a)_ / ____ (c) = ___ x 60 = ____/60
APPENDIX C: RANGE OF MOTION MEASUREMENT SHEET
Range of Motion Measurements

Subject # ____________________  Date___________________

ROM Measures

<table>
<thead>
<tr>
<th>Motion</th>
<th>Dominant (degrees)</th>
<th>Non-Dominant (degrees)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ER</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Arc</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

IRD – IRND = ________ degrees  Deficit ≥15°?  Y  N  
TAMD – TAMND = ________ degrees  Deficit ≥10°?  Y  N
APPENDIX D: TRIGGER POINT IDENTIFICATION SHEET
Trigger Point Identification

Teres Minor – Side lying

Latissimus Dorsi – Supine 90° ABD
Infraspinatus – Side lying

Posterior Deltoid – Side lying
Fresno State

Non-Exclusive Distribution License
(to archive your thesis/dissertation electronically via the library’s eCollections database)

By submitting this license, you (the author or copyright holder) grant to Fresno State Digital Scholar the non-exclusive right to reproduce, translate (as defined in the next paragraph), and/or distribute your submission (including the abstract) worldwide in print and electronic format and in any medium, including but not limited to audio or video.

You agree that Fresno State may, without changing the content, translate the submission to any medium or format for the purpose of preservation.

You also agree that the submission is your original work, and that you have the right to grant the rights contained in this license. You also represent that your submission does not, to the best of your knowledge, infringe upon anyone’s copyright.

If the submission reproduces material for which you do not hold copyright and that would not be considered fair use outside the copyright law, you represent that you have obtained the unrestricted permission of the copyright owner to grant Fresno State the rights required by this license, and that such third-party material is clearly identified and acknowledged within the text or content of the submission.

If the submission is based upon work that has been sponsored or supported by an agency or organization other than Fresno State, you represent that you have fulfilled any right of review or other obligations required by such contract or agreement.

Fresno State will clearly identify your name as the author or owner of the submission and will not make any alteration, other than as allowed by this license, to your submission. **By typing your name and date in the fields below, you indicate your agreement to the terms of this distribution license.**

**Embargo options (fill box with an X).**

- [x] Make my thesis or dissertation available to eCollections immediately upon submission.
- [ ] Embargo my thesis or dissertation for a period of 2 years from date of graduation.
- [ ] Embargo my thesis or dissertation for a period of 5 years from date of graduation.

**Joseph Gil**

Type full name as it appears on submission

**June 3, 2015**

Date